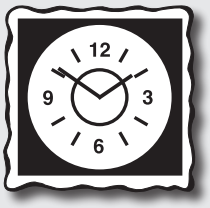
The Next Eruption of Mount Rainier



Grade Level: 6-12

Learner Objectives:

Students will:

- Identify how volcano hazards differ from other natural hazards in timing, duration and style.
- Expect future eruptions at many Cascade volcanoes, including Mount Rainier.
- Become familiar with methods used by scientists to watch for indications of renewed volcanic unrest and for lahars.
- Understand that scientists make hazard maps to identify areas that could be affected during future volcanic eruptions.
- Recognize some of the ways that volcanoes can impact a society's infrastructure and methods for mitigation.
- Recognize that volcanic eruptions are survivable, especially with proper precautions.
- Recognize that they can play an important role by bringing an understanding of volcanic risk to their family, school, and community, now and in the future.

USGS science for a changing world

Living with a Volcano in Your Backyard- An Educator's Guide with Emphasis on Mount Rainier

Prepared in collaboration with the National Park Service

U.S. Department of the Interior
U.S. Geological Survey

General Information Product 19

Overview

In this activity, students use Mount Rainier as an example while they explore a variety of themes associated with future volcanic activity. Students make a timeline of Mount Rainier volcanic events, interpret hazard maps, investigate potential effects on people and infrastructure, learn how scientists watch for signs of volcanic unrest, and create a warning statement. All products can be included in a "school volcano museum" for students and parents to view.

Teacher Background

What are the hazards?

Scientists recognize that Mount Rainier will erupt again. They consider it an active volcano because of four factors:

- Location on an active ***subduction zone***
- Presence of ***earthquakes*** beneath the volcano
- Active hydrothermal system within the volcano
- Recentness of volcanic ***eruptions*** in ***geologic time*** (on multiple occasions during the 19th century)

Last modified: May 7,, 2009

Setting: Classroom and homework

Timeframe:

"Mount Rainier Timeline" –50 minutes

"Reading Hazard Maps" –50 minutes

"Eyes and Ears on Mount Rainier" –50 minutes

"The Volcano and Your Community": homework and 30 minutes for class discussion

"Eyes and Ears on Mount Rainier" –50 minutes

"Volcano Evacuation Route Sign" –30 minutes

"Educating Future Generations -- The Granatello Epigraph" –50 minutes

Materials:

"Mount Rainier Timeline"

- Graphic *"Summary of Notable Events at Mount Rainier, 10,000 Years Ago to Present"*
- Adding machine tape

"Reading Hazard Maps"

- Graphic *"Lava and Pyroclastic Flow Hazard Zones on Mount Rainier"*
- Graphic *"Lahar Hazard Zones from Mount Rainier"*
- Graphic *"Lahar Hazard Map Extensions"*
- Graphic *"Effects of Volcanic Processes"*
- Graphic *"Prepare for Volcanic Unrest"*

"The Volcano and Your Community"

- Facilities for library or Internet research
- Graphic *"Volcano Evacuation Route Sign"*

Volcanic eruptions are unique among natural events

Volcanic ***eruptions*** are unique among natural events because they present multiple uncertainties about when eruptive activity will begin, how long it will last, and who will be affected. Unlike floods and earthquakes, volcanic eruptions are seldom singular events. ***Volcanic unrest***, when the volcano shows signs of reawakening, is often prolonged over a period of months to years with no predictable end. Sometimes it results in an eruption, and sometimes not. Even without an eruption, the uncertainty associated with volcanic unrest can cause repeated or long-term evacuations and psychological stresses, and thus bring major impacts on populations at ***risk.***

Volcanic processes—nuisances or disasters

Volcanic activity occurs in a variety of sizes, patterns, durations, and styles. Volcanic processes can be simply a nuisance or cause disaster, depending upon their nearness to communities. Fortunately, symptoms of rising ***magma*** can be identified and measured, and people at risk generally have some time to invoke response plans and evacuate to safer terrain. However, people at risk must be advised *beforehand* about how ***volcanic hazards*** might affect their area so that they know how to prepare and can make risk-wise decisions before the onset of volcanic unrest. People at risk should become aware of strategies for ***mitigation*** that have been established by officials in their community.

"Eyes and Ears on Mount Rainier"

- Graphic *"Volcano Monitoring Techniques"*
- Graphic *"The USGS Alert-Notification System for Volcanic Activity"*
- Facilities for library or Internet research
- Volcano Evacuation Route Sign
- Graphic *"Volcano Evacuation Route Sign"*

"Educating Future Generations-- The Granatello Epigraph"

- Graphic *"Text of Granatello Epigraph, Portici, Italy"*
- Poster paper
- Art materials

Vocabulary: Active volcano, ashfall, bombs, blocks, conduit, earthquake, emergency plan, epigraph, eruption, explosion, gas, family emergency preparedness plan, geologic time, geothermal, hazard, hazard map, hydrothermally altered rock, infrastructure, lahar, lava flows, magma, magmatic eruption, monitor, mitigation, pyroclastic flows, risk, subduction, tephra, vent, volcano, volcanic ash, volcanic gases, volcanic hazards, volcanic unrest

Skills: Apply, interpret, participate, explain, research, debate, clarify, draw conclusions

Benchmarks:

Please see the Mount Rainier National Park Education Program website for the most recent alignment of these activities with Washington State and nationally approved education standards.

http://www.nps.gov/mora/forteachers/curriculummaterials.htm

Recent eruptions at Mount Rainier

Small eruptions were reported in local newspapers during the nineteenth-century (see **Nineteenth-Century Newspaper Accounts of an Eruption at Mount Rainier**). The last eruptions to cause significant change to the shape of Mount Rainier happened approximately 1,000 years ago. Some of these most recent eruptions built the two summit craters visible today, and spewed small ***lava flows*** onto the northeast flank of the volcano. Perhaps thousands of local inhabitants witnessed this eruption. The next eruption of Mount Rainier could be witnessed by millions of people.

A likely scenario for the next magmatic eruption of Mount Rainier

Scientists believe that future eruptions will likely resemble events that occurred repeatedly during Mount Rainier's past. Volcanic unrest at Mount Rainier might begin with an increase in earthquake activity, accompanied by increases in the release of carbon dioxide, sulfur dioxide and other ***volcanic gases*** from a ***vent***, and a visible, persistent steam plume. This precursory activity could continue for weeks, months or longer and lead to a variety of outcomes. The unrest could subside and the volcano could return to sleep. Or, increased ***geothermal*** heating might cause small steam ***explosions*** at the summit, but no eruption of fresh magma. Less commonly, magma from deep within the earth could rise into the volcano and cause a ***magmatic eruption***. It might begin with a blast of ***tephra*** and hot volcanic gases. Large pieces of tephra would drop onto the volcano's slopes while finer-grained ***volcanic ash*** would be blown by the wind and fall to the ground many kilometers (or miles) from Mount Rainier. Volcanic ***bombs*** and ***blocks*** might bombard the surface of the volcano. A lava lake might rise within the crater and spill over the rim to form lava flows. On a steep-

sided volcano such as Mount Rainier, lava flows would break apart and descend the slopes as avalanches of hot rock and gas known as ***pyroclastic flows***, which could melt snow and ice and produce ***lahars*** (volcanic mudflows). Large lahars could rush down valley as far as 120 kilometers (70 miles) from the volcano. Landslides of wet ***hydrothermally altered rock*** could be shaken loose from the flanks of the volcano and thunder down the valleys as lahars.

Eruption hazards can affect people near and far

In the past, lava and pyroclastic flows have not traveled beyond the cone of Mount Rainier and at present, there is no reason to assume that they will do so in the future. However, the lahars produced by melting ice and snow have been found as far as 100 kilometers (60 miles) from the volcano. Lahars are the principal hazard at Mount Rainier because they travel far from the volcano to areas that are now densely populated. At least 80,000 people now live, work, and go to school in lahar hazard zones. We can expect that volcanic ash will fall in the largest quantities near the volcano and in progressively smaller amounts farther away. The severity of volcanic ***ash fall*** will depend upon the amount erupted, wind speed and direction.

Volcanic eruptions are survivable when people take proper precautions

Over the millennia, millions of people have experienced the fear and splendor of volcanic eruptions, and learned that volcanic eruptions are survivable when safety precautions are taken. Societies respond best when their citizens understand the hazards, when they can identify areas at risk, and are knowledgeable about how to respond during volcanic unrest.

Plan now to maintain infrastructure during volcanic eruptions

The term ***infrastructure*** refers to all services and facilities that support functioning of a community, such as electrical power, water, sewer, transportation and communication systems, schools, police and fire departments, hospitals, and prisons. Managers of these systems should coordinate their emergency planning efforts now so that services remain uninterrupted or are quickly restored after a disaster. A society can reduce the risk to people by limiting dense settlement in the paths of lahars, by educating entire populations about proper response measures, preparing ***emergency plans***, and planning and practicing evacuations.

Preparing for the next eruption

Working with a long record of hazardous natural events and recognition of effects on humans, the American Red Cross and emergency management agencies assembled a variety of materials that serve as guides for preparations during an emergency. Some examples of preparations are community education and development of evacuation plans, ***family emergency preparedness plans***, and preparedness kits. These materials provide a basis for discussion and planning efforts in families, schools and communities. When people become knowledgeable about volcanic processes, they can prepare for volcanic events and then live with greater safety, comfort and enjoyment in their communities.

One example of a community planning effort—Mount Rainier

During the 1990s, emergency managers, educators, park and other public officials, community leaders and scientists established the Mount Rainier Volcano Hazards Work Group, which is dedicated to mitigating the effects of future volcanic activity at Mount Rainier. The group developed a volcano response plan, which defines the roles of agencies during volcanic crisis. This group practices its emergency plan, trains emergency responders, and supports public educational efforts, including installation of evacuation route signs. Pierce County Department of Emergency Management maintains a lahar-detection and notification system that warns of approaching lahars.

How prepared is your community?

As of this writing, scientists and land and emergency managers have written a volcano response plan for each of the Cascade volcano in Washington and Oregon. Find emergency response plans at websites listed on the **Internet Resources Page**.

Reading volcano hazard maps

Scientists developed hazard maps for most of the major Cascade volcanoes and for many hazardous volcanoes around the world to help emergency and land-use managers, community leaders, scientists, and citizens develop preparedness plans. While no one can predict precisely how large the next eruption or lahar will be, scientists who have examined the extent of deposits formed during previous volcanic eruptions, make best estimates of localities that might be affected in the future. We repeat for emphasis—*these maps are best approximation of areas the might be directly affected* by the volcanic processes noted below.

- **Graphic *"Lava and Pyroclastic Flow Hazards at Mount Rainier"***
  In the past, lava and pyroclastic flows have not traveled beyond the cone of Mount Rainier and at present, there is no reason to assume that they will do so. Scientists based their hazards map upon this assumption, with the recognition that future events can be larger or smaller than the hazard zones displayed on the map.

- **Graphic *"Lahar Hazard Zones from Mount Rainier"***
  The lahar hazard map is based upon the extent of previous geologic events. To develop hazard zonation for lahars, scientists measured the extent of the Election Mudflow of around 1500 A.D. and used this information as a guide to which areas might be covered by the next lahar. Debris Flows, small versions of lahars that are formed by intense rainfall and sudden glacial outbursts floods, are *seldom large enough to travel beyond park boundaries*. See the activity **Lahar in a Jar** for more information about previous lahars at Mount Rainier.

- ***Prediction of volcanic ashfall***
  The size of an ash cloud and location of ashfall depends on the size of the eruption and wind speed and direction. Atmospheric data provides the basis for prediction about which up-to-the- hour analysis, indicating the most likely location of ashfall. See the activity **Volcano Fan Club** and **Internet Resources Page** for instructions about computer-generated programs that track the most likely destination of volcanic ash, based on current wind speed and direction.

Eyes and ears on Mount Rainier

When it comes to keeping track of activity at volcanoes, volcanologists are a bit like professional athletes. The athlete tries to figure out an opponent's next move by examining past records and by keeping a close watch on them during a game. In the same way, volcanologists must study a volcano's past activity and keep a close watch on a volcano's current conditions. These actions allow volcanologists to know, in a general way, what styles of eruption could happen, and to spot any signs of rising magma that might lead to an eruption. Until magma shows some evidence of ascent toward the surface, scientists have no way to forecast when a volcano will reawaken.

The first evidence of a potential eruption is usually earthquake activity caused by rising magma, which cracks and breaks brittle rock. These earthquakes are often accompanied by deformation of the landscape, whereby some segments of the landscape rise and others subside. These variations in ground surface help scientists calculate the amount of magma in the ***conduit***, its position relative to Earth's surface, and how soon the volcano will erupt. The fracturing and breaking of rocks permits the release of gases from the rising magma.
There is no set formula for forecasting volcanic eruptions because volcanoes do not always follow a well-defined, pre-determined sequence of events preceding volcanic activity. Scientists use a combination of data analysis and scientific judgments to assess the likelihood of an eruption.
Although the onset of a period of volcanic unrest remains unpredictable, some generalized forecasting about the timing and potential style of an eruption is possible, but only after volcanic unrest has been detected. Once signs of rising magma are observed, they can analyze the patterns of earthquakes, gas release, and ground deformation, and judge the likelihood of an eruption. When a volcano shows signs of unrest, or if it is erupting, scientists visit the volcano as often as possible to make observations and to install additional monitoring instruments that enable them to track the volcano's activity 24 hours a day.

Consult the **Internet Resources Page**, or use your Internet browser to locate information about emergency preparations, volcano response plans, evacuation plans, and educational efforts in your community.

Before you Begin:

Choose any or all of these activities for your students. After completion of the procedures, display students' products in a "school volcano museum" for viewing by other students and by their families. Your museum can include emergency preparedness information and student projects from other activities, such as **Cascade Volcano Timeline**, **Play-Dough Topo**, **Planning your Trip to Mount Rainier National Park!**, and **Living Well with a Volcano in your Backyard**.

Procedure:

A. Mount Rainier Timeline
B. Reading Hazard Maps
C. The Volcano and Your Community
D. Eyes and Ears on Mount Rainier
E. Volcano Evacuation Route Sign
F. Educating Future Generations—The Granatello Epigraph

A. Mount Rainier Timeline

Summary: Students use information in the table ***"Summary of Notable Events at Mount Rainier, 10,000 Years Ago to Present,"*** to make a timeline, then use it to examine the likelihood that volcanic events will occur within a human lifetime.

Instructions:

1. Divide the class into groups of two to four students.

2. Provide the graphic ***"Summary of Notable Events at Mount Rainier, 10,000 Years Ago to Present,"*** either projected or as a handout to student groups.

3. Give each group a strip of cash register or adding machine paper, or other paper taped together that is three meters (ten feet) long.

4. Have the students determine a time-scale, and then write the events and dates on the paper.

5. Students place it against the timeline beginning at the present, mark that lifespan on the timeline, and move progressively back through time.

6. Students fold a piece of notebook longwise into halves, twice, so that it resembles a ruler. This ruler represents an average human lifespan of 80 years. Students place it on the timeline to find the length of 80 years on the ruler, mark it, then

7. Engage students in a discussion about results. Students answer the questions below.

How many generations go by without any volcanic activity or lahars at Mount Rainier? Are there some generations during which more than one event occurs? Discuss with students the likelihood that most recent events are better documented, leading to the appearance that the volcano was more active in recent centuries.

B. Do you Live in a Volcano Hazards Zone?

Summary: Teacher leads students in discussion about areas likely to be affected by volcanic hazards associated with Mount Rainier. Show application to volcanoes globally by supplying students with Internet access to volcano images and maps.

Instructions:

1. Provide the graphics ***"Mount Rainier Volcanic Hazard Zones,"*** ***"Lahar Hazard Map Extensions,"*** and ***"Lava flow and Pyroclastic Flow Hazards at Mount Rainier,"*** projected or as a handout to student groups. Or, choose hazard maps for other volcanoes, available through the USGS Volcano Hazards Program website, and other resources (See **Internet Resources Page**). Explain that the lahar hazard map was developed by scientists who used maps of volcanic deposits from past eruptions as a guide to identifying areas at risk. Introduce maps to students. Remind students that all hazard zones are best approximations based on evidence from previous events and on scientists' best judgments.

2. Find your community (or other chosen community) on a volcano hazard map. Is it in a lahar hazard zone? Is this community at direct risk from lava and pyroclastic flows? Note that lahars travel in river valleys. Instruct students to develop advice for people to escape a lahar (get to high ground). Discuss why scientists cannot predict with precision how far lahars will travel. Ask students to explain how lava flows and pyroclastic flows can affect communities distant from a volcano (lahar generation by snow and ice melt). For more process-related discussions on these topics, refer to the activities **Lahar in a Jar**, **Lava Building Blocks**, and **Volcanic Processes**.

3. Remind students that the location and thickness of volcanic ash fall depends upon eruption size, and wind speed and direction during and after the eruption. Note that in the Pacific Northwest, the wind blows towards the east, northeast, or southeast 85 percent of the time, so areas east of Cascade volcanoes are more likely to receive ash fall. Ask students if their community is at risk, and engage them in discussion about the risk to communities across your state. Optionally, and for a more process-related discussion on this topic, refer students to websites with computer-generated programs that can track the most likely destination of volcanic ash, based on current wind speed and direction. See **Internet Resources Page**. Students can use the graphic ***"Effects of Volcanic Processes"*** and the student page ***"Prepare for Volcanic Unrest"*** to organize their thoughts.

4. If you have Internet access in your classroom, use web-based images and maps of planet Earth to analyze areas at risk from volcanoes. Use computer graphics based source and destination tools to quantify the area at risk and to measure distances from the volcano. Look for volcanoes and nearby cities. Students should make some quick analyses about the volcanic hazards that these population centers might face.

5. Instruct students to write one-page reports about volcanic hazards and useful risk reduction measures that could benefit their community. Students share the information with their family.

C. The Volcano and Your Community

Summary: Students play the roles of town officials who must prepare for the possibility that an eruption will affect their community's infrastructure. Students list potential hazards and facilities at risk, develop strategies for protection, and then stage a "town meeting" to report back to the town's citizens—the teacher and class members.

Instructions:

1. Begin with a class discussion about the volcanic hazards that place a community at risk. List these hazards. Display the graphic ***"Effects of Volcanic Processes,"*** or have students provide the information. Make the list of effects visible so that students can use them in instruction 2 below.

   Explain the definition of infrastructure. Note that infrastructure includes all the services and facilities that support day-to-day activity, such as electrical power, water, sewer, transportation (roads, bridges, trains, trucks, cars, airplanes, port facilities), communication systems, schools, police and fire departments, hospitals, and prisons. Discuss the dependencies that each has upon the other. For example, consider the difficulties of repairing water well facilities when the road system is inaccessible. Challenge students to list short-term and long-term effects to the local and regional economy. Encourage students to list specific populations at risk in high hazard zones, such as residents and tourists in valleys near the volcano. Within the resident population, discuss special needs populations, such as people under the age of five years and over 65, people who don't speak English as a primary language, renter-occupied houses, and economically-disadvantaged people. Consider dependent populations who need special assistance with evacuation. Some examples are people with disabilities, people in hospitals, jails, senior-citizen homes, day cares.

2. Divide the class into groups of 2 or 3 students. Assign one portion of community infrastructure (or a specific population group) to each student group. Students use information on the graphic to develop strategies for community protection. Instruct at least one group to develop strategies for community education and methods for informing communities about volcanic hazards. Students can use findings on the ***"Prepare for Volcanic Unrest"*** student page. They should visit websites listed on the **Internet Resources Page** to determine what actions are being taken to mitigate volcanic hazards, then prepare a video, oral or computer-projected presentation or written summary about protective strategies. Students stage a "town meeting" and present their results.

3. Optional—Use the emergency management addresses in the **Internet Resources Page** to obtain a volcano hazards response plan that addresses volcanic hazards in a community. Encourage class discussion about how the components of the plan can help save life and property during a volcanic event.

D. Eyes and Ears on Mount Rainier

Summary: Students answer guiding questions to learn about the components of volcano monitoring. They write summary reports about their research, or produce a video or computer-projected presentation, or talk about their results.

Instructions:

1. Begin your discussion of volcano monitoring by asking guiding questions that lead students to develop monitoring strategies. Tell students that they should muster all their critical thinking skills so that they can think like a physician who watches the "health" of a patient by making examinations and looking for clues of an illness. Then, ask students what symptoms of rising magma would be detectable from Earth's surface (most typical symptoms are earthquake swarms, swelling or subsidence of the land surface, ***gas*** measurements, temperature changes). How could scientists detect magma rising beneath a volcano? (recording the shaking of earthquakes, measuring land surface changes, and making measurements of ground temperatures and gases).

   Data collected by volcano-monitoring networks makes possible the early detection of volcanic unrest usually days to months or more before an eruption. The most effective monitoring is achieved by using a combination of techniques that detect changes in earthquake activity, changes in gas release, ground deformation, and changes in hydrological conditions, as listed on the graphic ***"Volcano Monitoring Techniques."*** Begin your discussion by asking what types of tools scientists could use. For example, seismographs and similar recorders measure ground shaking; Global Positioning System (GPS) units, cameras, tiltmeters, satellite-based distance measuring techniques (Interferometric Synthetic Aperture Radar, also known as InSAR,) and surveying instruments measure land movement; ground and airborne thermal and gas sensors measure heat sources and gas release.

2. Display the graphic ***"Volcano Monitoring Techniques."*** Note to students that the data collected from volcano monitoring networks make the early detection of volcanic unrest possible and are critical for interpreting volcanic processes, forecasting eruptions, and predicting likely impacts of eruptions. How many types of monitoring do they see on the graphic? (nine) Ask the students about some of the challenges that scientists might encounter as they monitor a volcano (steep terrain, bad weather, volcano unrest threatening, and equipment failures). Tell students that a volcano is a hazardous place for people and equipment. Can scientists obtain the data without visiting the volcano? How so? (earthquake data, ground deformation measurements and automated camera

shots commonly are sent by radio from the volcano to the scientists at their observatory). Volcano visits are required for setup and maintenance of equipment, for use of some instruments, and for visual observations. Ask students how scientists can know when conditions on the volcano have changed from normal. Encourage discussion on the importance of making measurements at volcanoes before, during and after volcanic eruptions.

3. Instruct students to conduct research from books and websites, such as that of the U.S. Geological Survey's Volcano Hazards Program, to determine the most up-to-date techniques for monitoring volcanoes. Students should write summary reports about their research, or produce a video or computer-projected presentation. Encourage students to find current news reports about ongoing volcanic activity and the techniques that scientists use to watch hazardous volcanoes. Show the graphic ***"The USGS Alert-Notification System for Volcanic Activity,"*** and encourage students to become familiar with it. See resources on the **Internet Resources Page.**

E. Volcano Evacuation Route Sign

Summary: Students answer questions about the evacuation route sign and about hazards in their community. They use the ***"Prepare for Volcanic Unrest"*** student page and the ***"Effects of Volcanic Processes"*** graphic to make decisions about whether it is better to remain in their community, or evacuate during a volcanic eruption.

Instructions:

1. Begin a discussion about the ***"Volcano Evacuation Route Sign"*** graphic. Display the graphic and ask students if they have seen this sign in their community. Do they know what it means? Lead a discussion about the value of the signs. Be certain that students understand that the signs indicate routes to high ground, away from potential lahar paths. Be sure that student know that during other hazards, such as from volcanic ashfall, staying inside may be the best action.

2. Instruct students to complete the information on the bottom of the Student Page then take it home and display it for the safety of their family. Ask the students for suggestions about how to increase the effectiveness of the signs.

3. Assign library and Internet research that examine the need to remain in or evacuate their community during volcanic eruptions. From library or Internet searches they learn appropriate procedures. Light ashfall requires them to remain indoors; lava eruptions which can produce lahars might require them to evacuate from a lahar hazard zone.

F. Educating Future Generations – The Granatello Epigraph

Summary: The December, 1631 eruption of Mount Vesuvius, near Naples, Italy was one of the most violent and destructive in the volcano's history. During this three-day event, pyroclastic flows swept over the densely populated slopes of the volcano, killing approximately 6,000 people. The city of Portici, just five kilometers (three miles) from the crater, was hit particularly hard. As a warning to future generations, Viceroy Emmanuel Fonseca commissioned the construction of an inscribed stone monument, known as an ***epigraph.*** The inscription was intended to warn future generations about the destructive power of the volcano. Dense urban development now surrounds the Granatello Epigraph, a reminder of how quickly a disaster can be forgotten, and about the importance of continual education and planning for future volcanic eruptions.

Instructions:

1. Keep the issue in perspective. Inform students (or have students do research) about the differences in hazardous phenomena at Mount Vesuvius and at Cascade volcanoes. (Pyroclastic flows and dense tephra fall place people at risk at Vesuvius while lahars are the principal hazard to population centers near the Cascade volcanoes. Large populations live on the slopes and at the base of Vesuvius, while population centers exist farther from volcanic vents of most Cascade volcanoes.) Read or visually project the text of the epigraph on the ***"Granatello Epigraph"*** graphic. Discuss its meaning with the class. You might introduce the concepts of "hazard"—any physical process that can cause damage, harm or adverse effects, and "risk," the chance or probability that people or property will be harmed or experience an adverse effect if the event were to happen.

2. Instruct students to recall what they have witnessed or heard about a volcanic event or other natural hazard that took place within their lifetime. Students should create a list of warning statements for future generations, in a manner similar to those written on the Granatello Epigraph.

3. Provide materials for students to make their own warning sign for future generations Materials might take the form of a poster, story board, a time capsule to their children, or a clay model.

Adaptations

- Use modeling clay on a relief map to simulate large glaciers from the ice age. Lift the modeling clay and examine the shapes on the underside. Students note that the clay glaciers are thicker in valleys between the ridges.

- Students fold a piece of paper into six equal portions. They draw pictures in sequence of six volcanic processes that occur before, during and after an eruption at Cascade volcanoes such as Mount Rainier. Students illustrate earthquake motion, escape of gases, tephra eruption, lava flows, pyroclastic flows, and lahars.

- Use Internet Browsers to find satellite images of volcanoes and population centers that are at risk. Challenge students to find evidence of volcanic activity and areas that might be at risk.

- Instruct students to read The Granatello Epigraph, individually or in small groups, and write what it means in their own words. Discuss the writings as a class.

- In some volcanic regions, groups of public officials, community leaders, educators and other concerned citizens have established volcano work groups to develop strategies for reducing volcanic risk. A response or coordination plan defines the problems and the roles of official groups to address during a crisis. Instruct students to conduct an Internet search for these plans. In Washington State, they are found at the Emergency Management Division website.

Extensions

- Instruct students to do a library or Internet search for methods used to mitigate volcanic hazards around the world.
- Obtain a map of volcano evacuation routes. Trace the routes to high ground for neighborhoods in your area.
- Visit the website of the U.S. Geological Survey's Volcano Hazards Program (see **Internet Resources Page**) and view pages entitled "Predicting volcanic eruptions." This program provides a very simplified synopsis of changing conditions prior to a volcanic eruption.

Assessment

Assess students' ability to apply their learning about volcanoes to a real-world situation. Students who are just beginning a study of volcanoes might not recognize the presence of volcanoes near their own community. They might not comprehend the nature and scale of volcanic processes that threaten their community. At the end of their study, students should be aware of the localities of nearby volcanoes and able to identify the hazards to their community. Instruct students to work in groups as they develop, in their own words, a written assessment of volcanic hazards at a volcano of their choice. They should make a plan for how to determine the economic impact on their community, develop some ideas for risk reduction, and discuss how to educate citizens about the hazards. Look for evidence of real-world understanding of the hazards and the social aspects. Students can present their information in a poster or report, or as a computer projected or oral presentation.

References

Find hazards assessments and volcano fact sheets for many volcanoes within the United States and its territories on the web pages of the U.S. Geological Survey. Response plans for some volcanoes are posted at emergency management websites. Some products, primarily focused on Mount Rainier, are listed on the **Internet Resources Page**.

Dent-Cleveland, Laurie, 2003, The beautiful mountain in the sky—How to be safe if a lahar flows down the mountain: Washington Military Department—Emergency Management Division, Elementary Edition K-6 Booklet: 24 p.

Driedger, C. and Scott, W., 2008, Mount Rainier--living safely with a volcano in your backyard: U.S. Geological Survey Fact Sheet 2008-3062, 4p.

Dzurisin, D., Stauffer, P., and Hendley, J., 2003, Living with volcanic risk in the Cascades (revised March, 2008): U.S. Geological Survey Fact Sheet 165-97, 2p.

Hoblitt, R.P., Walder, J.S., Driedger, C.L., Scott, K.M., Pringle, P.T., and Vallance, J.W., 1998, *Volcano hazards from Mount Rainier, Washington*, Revised 1998: U.S. Geological Survey, Open-File Report 98-428, 11 p.

Mount Rainier Volcano Hazards Work Group, 2008, *Mount Rainier volcano hazards response plan*: Pierce County Department of Emergency Services, 93 p. (available at emergency management websites listed on **Internet Resources Page**.)

Sisson, T.W., 1995, History and hazards of Mount Rainier, Washington: U.S. Geological Survey Fact Sheet 95-642, 2 p.

Sisson, T.W., Vallance, J.W., and Pringle, P.T., 2001, Progress made in understanding Mount Rainier's hazards: EOS, Transactions of the American Geophysical Union, v.82, p. 116-120.

Refer to **Internet Resources Page** for a list of resources available as a supplement to this activity.

Graphic Page

Summary of Notable Events at Mount Rainier, 10,000 years ago to Present

Age or Date	Event	
A.D. 1980's to present	Several dozen debris flows in river valleys that head on Mount Rainier	
A.D. 1963	Rock fall avalanche from Little Tahoma Peak	
A.D. 1947	Debris flow and runout flow of glacial-outburst origin in Kautz Creek	
A.D. 1930's to 1950's	Multiple debris flows in Nisqually valley	
A.D. 1910-1927	Rock avalanche on Tahoma Glacier	
A.D. 11894-1895	Reports of small steam and ash eruptions at summit	
500 years ago	Rock avalanche-induced Electron Mudflow in Puyallup/Nisqually river valleys; no documented association with volcanic eruptions	
1,100 to 1,000 years ago	Lahar down Puyallup River at least as far as its confluence with Mowich River	National Lahar in Nisqually River valley sometime between 2,200 and 500 years ago
	Tephra and lahars in White River valley as far as Kautz Creek	
1,500 years ago	Tephras and lahars in valleys of the White River and Kautz Creek	
2,000 years ago	Lava flows formed summit cone, Columbia Crest	
2,200 years ago	Eruption of Layer C tephra	
2,200 to 2,600 years ago	Lahar in Nisqually River valley deposits sandy layers	
2,400 to 2,500 years ago	Eruption of block-and-ash flow in Puyallup River valley; Eruption of tephra layers	
2,600 years ago	Lahar-Round Pass mudflow descended Puyallup valley to Puget Sound lowland. Part of it descended Tahoma Creek and the Nisqually River	
2,200 to 2,700 years ago	Multiple lahars in White River Valley	
4,500 years ago	Eruption of tephra layer B	
4,700 years ago	Eruption of tephra layer H	
5,600 years ago	Lahar- Osceola Mudflow in White River's main branch and West Fork extended to Puget sound lowland. Eruption of tephra layer F; Paradise Lahar (part of the Osceola Mudflow) in Nisqually River Valley, extended as far as the community of National	
>5,600 years ago	Eruption of tephra layer S	
6,700 years ago	Eruption of tephra layers N and D	
7,200 to 7,400 years ago	Eruption of volcanic bomb-bearing rocks and lahars in White River Valley	
7,200 to 7,400 years ago	Rock avalanche-induced lahar down the Nisqually River and at Reflection Lakes	
7,200 to 7,400 years ago	Eruption of tephra layers L and A	
11,000 years ago	Eruption of tephra layers L and R	

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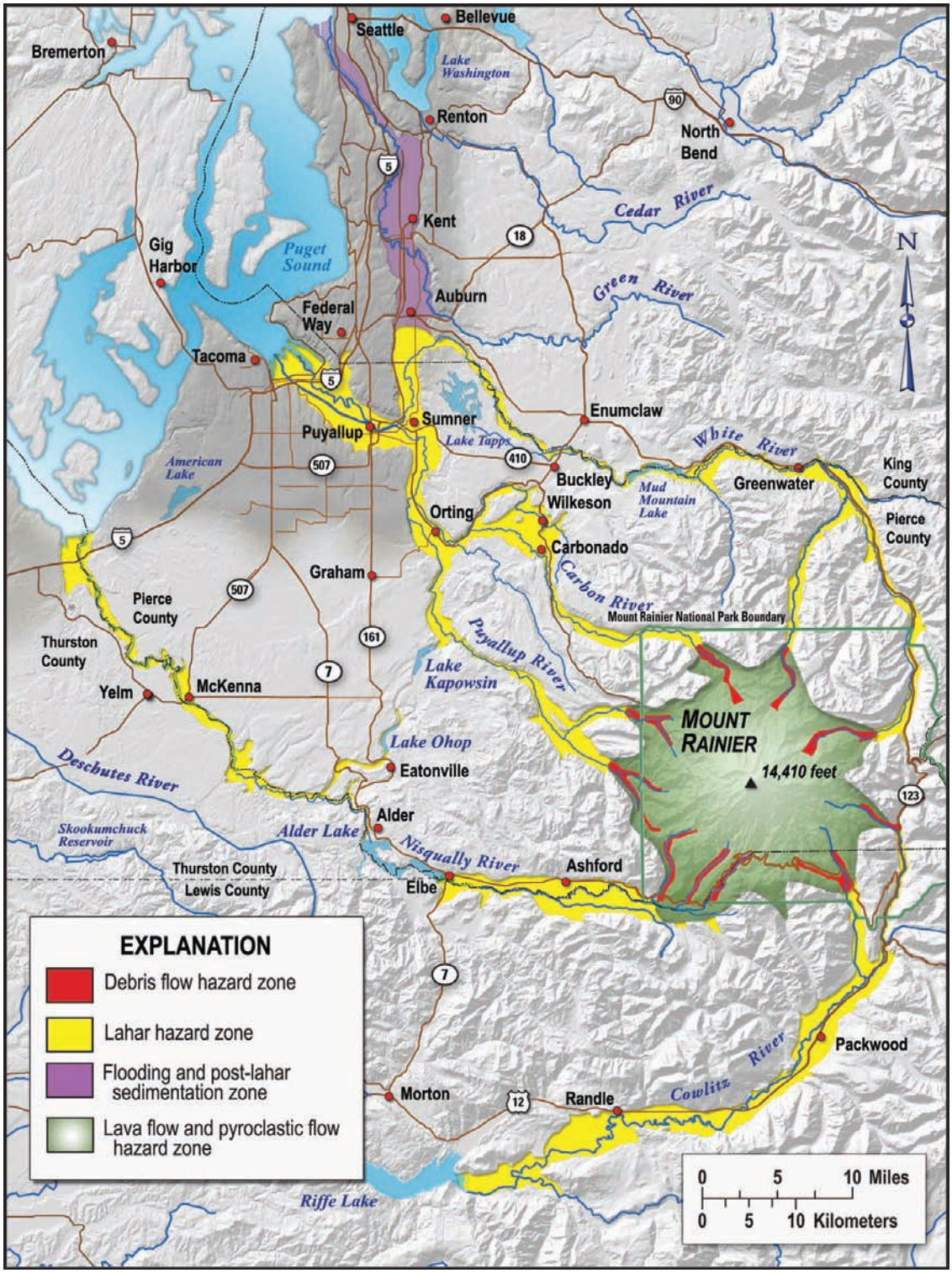
Mount Rainier Volcanic Hazard Zones



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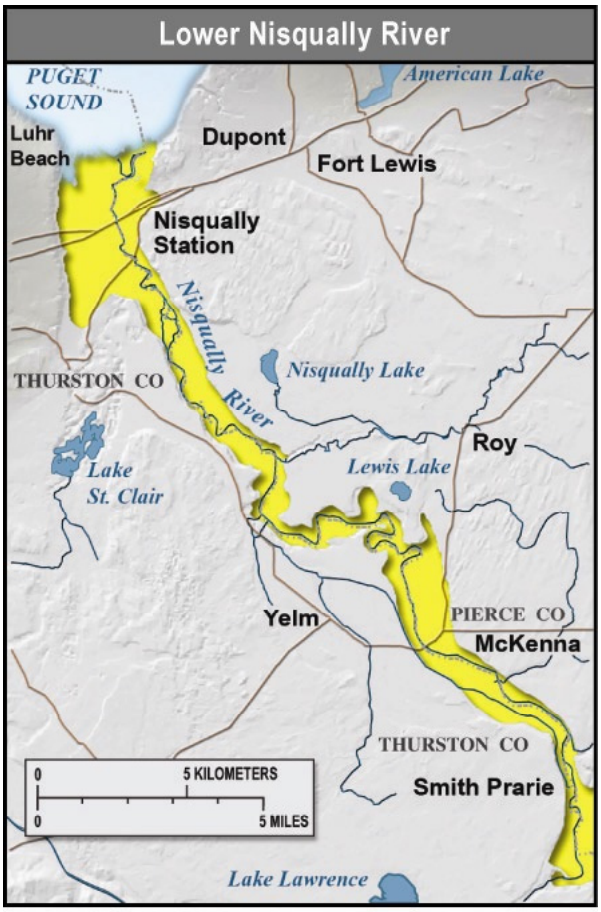
Lahar Hazard Map Extensions



Revised October, 2008

Revised October, 2008

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Effects of Volcanic Processes

Volcanic Process	Effects
Ashfall	Affects people distant from the volcano
	Makes breathing difficult
	Irritates eys
	Reduces visibility
	Abrades machinery , equipment and computer systems
	Damages jet engines and can cause aircraft equipment failures
	Clogs filters
	Causes electrical shorts
	Strips leaves from crops and trees
	Collapses buildings when wet and in excess of 10 cm (4 inches)
Lahars	Destroys or buries all in their path by impast or by burial
	Can travel at speeds that exceed 60 km per hour (40 miles per hour)
	Csn fill river channels and cause long-term flooding
Lava Flows and Pyroclastic Flows	Destroy all in their path by burning, burial or asphyxiation
	Can melt ice and snow and cause lahars
Volcanic Gases	Generally hazardous only when people come in contact with gases in confined spaces

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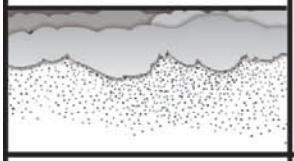
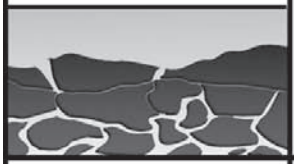
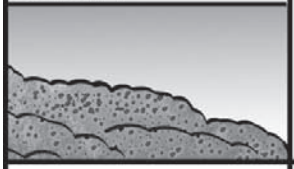
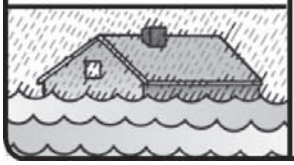
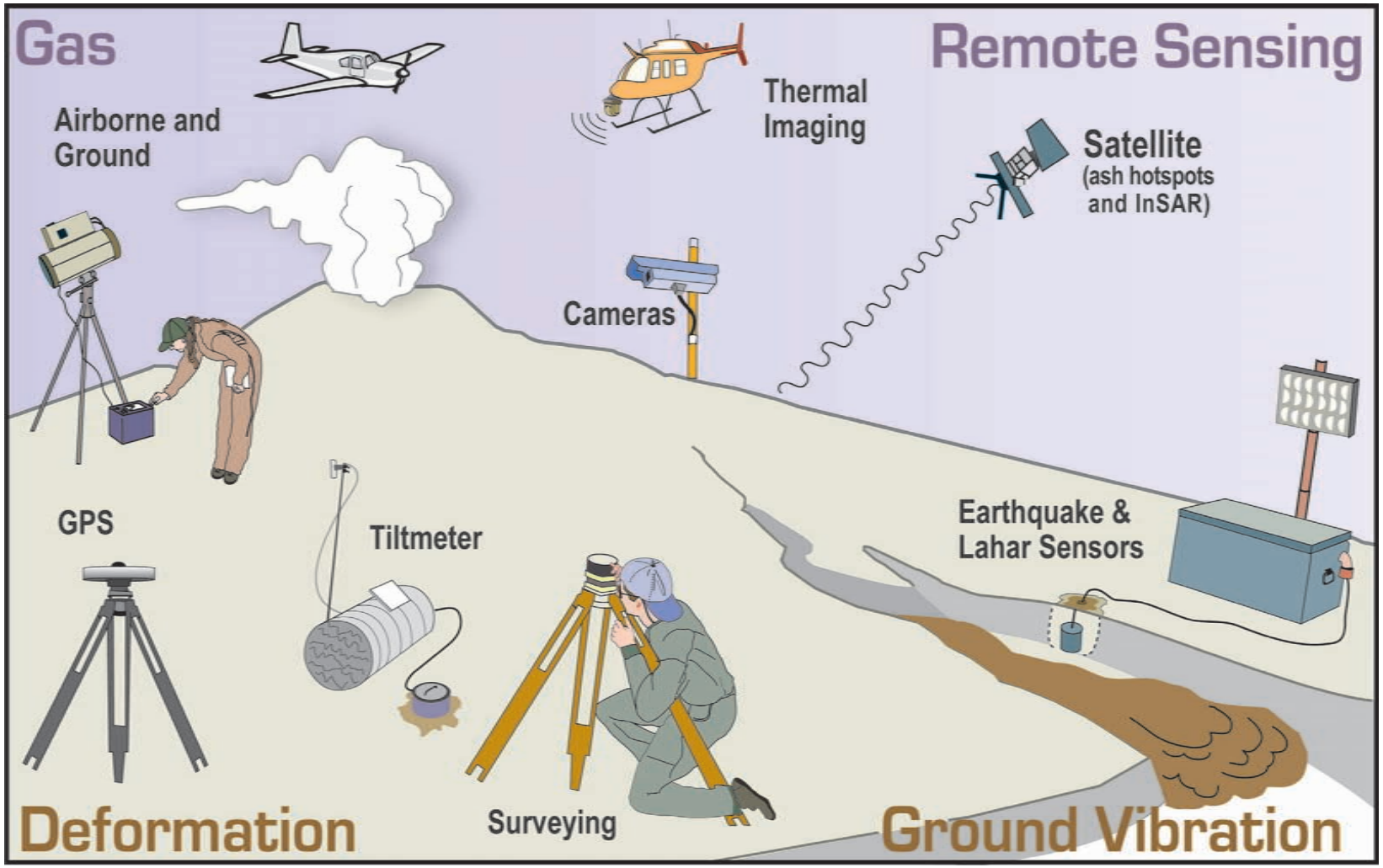
LIBRARY WEB

Prepare for Volcanic Unrest

Instructions: *Conduct an Internet or library search for materials that advise you about how to prepare for each of the following volcanic processes.*

Type of Hazard	What are the Hazards?	How Could the Hazard Affect Your Community-Directly or Indirectly?	How Will You andYour Family or School Group Become Prepared?
Volcanic Ashfall 			
Lava Flows 			
Pyroclastic Flows 			
Lahars 			
Floods 			

Volcano Monitoring Techniques



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The USGS Alert-Notification System for Volcanic Activity

Volcano Alert Levels Used by U.S. Volcano Observatories

Alert levels are intended to inform peopel on the ground about a volcano's status and are issued in conjunction with the Aviation Color Code. Notifications are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption and about potential or current hazards and likely outcomes.

Term	Description
NORMAL	Volcano is in typical background, noneruptive state or, *after a change from a higher level,* volcanic activity has ceased and volcano has returned to noneruptive background state.
ADVISORY	Volcano is exhibiting signs of elevated unrest above known background level or, *after a change from a higher level* volcanic activity has decreased signicantly but continues to be closely monitored for possible renewed increase.
WATCH	Used in two different situations: Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, **OR** eruption is underway but poses limited hazards.
WARNING	Hazardous eruption is imminent, underway, or suspected.

Aviation Color Code Used by U.S. Volcano Observatories

Color codes,which are in accordance with recommended International Civil Aviation Organization (ICAO) procedures, are intended to inform the aviation sector about a volcano's status and are issued in conjuction with and Alert Level. Notificiations are issued for both increasing and decreasing volcanic activity and are accompanied by text with details (as known) about the nature of the unrest or eruption, especially in regard to ash-plume information and likely outcomes.

Color	Description
GREEN	Volcano is in typical background, noneruptive state or, *after a change from a higher level,* volcanic activity has ceased; and volcano has returned to noneruptive background state.
YELLOW	Volcano is exhibiting signs of elevated unrest above known background level or, *after a change from a higher level,* volcanic activity has decreased signicantly but continues to be closely monitored for possible renewed increase.
ORANGE	Volcano is exhibiting heightened or escalating unrest with increased potential of eruption, timeframe uncertain, **OR** eruption is underway with no or minor ash emission height specied, if possible].
RED	Eruption is imminent with signicant emission of ash into the atmosphere likely **OR** eruption is underway or suspected with signicant emission of ash into the atmosphere [ash-plume height specied, if possible] .

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Volcano Evacuation Route Sign

Our Community's Beautiful Backyard Volcano

Volcano nearest to my community:_____

Last Eruption_____

Hazards from volcano_____

Specific steps for my family before and during a volcanic event:_____

_____

Learn: *Learn whether you live, work, or go to school in a volcano hazard zone.*
Inquire: *Ask public officials how they advise you to respond.*
Plan: *Plan for how you and your family can be prepared for emergencies.*
Participate: *Participate in helping your community be prepared!*

Graphic Page

Granatello Epigraph

DESCENDENTS, DESCENDENTS, IT IS ABOUT YOU!
TODAY ILLUMINATES TOMORROW WITH ITS LIGHT. LISTEN!
TWENTY TIMES SINCE THE SUN ROSE, IF HISTORY DOES NOT TELL STORIES,
THE VESUVIUS BURST INTO FLAMES,
ALWAYS WITH HUGE EXTERMINATION OF THOSE WHO HESITATED.
I WARN YOU SO THAT IT DOES NOT FIND YOU UNDECIDED.
THIS MOUNTAIN HAS ITS WOMB HEAVY WITH PITCH, ALUM, IRON, SULPHUR,
GOLD, SILVER, SALTPETER, AND SOURCES OF WATER.
SOONER OR LATER IT CATCHES FIRE AND WITH THE AID OF THE SEA IT DELIVERS.
BUT BEFORE DELIVERING, IT SHAKES ITSELF AND SHAKES THE GROUND.
IT SMOKES, REDDENS, FLARES UP. IT RAVAGES HORRIBLY THE AIR.
IT HOWLS, ROARS, THUNDERS, AND CHASES THE INHABITANTS OF THE
NEIGHBORING AREAS AWAY.

RUN AWAY WHEN YOU ARE STILL ON TIME!

HERE IT IS FLASHING, EXPLODING, VOMITING LIQUID
MATTER MIXED WITH FIRE, WHICH FLOWS HEADLONG,
CUTTING DEFAULTERS' WAY OFF.

IF IT REACHES FOR YOU IT IS OVER. YOU ARE DEAD.

IT PUNISHES INCAUTIOUS AND GREEDY PEOPLE WHO
CARE MORE FOR THEIR HOUSES AND FURNISHINGS
THAN FOR THEIR LIFE.

IF YOU ARE WISE LISTEN TO THE VOICE OF THIS STONE.

DO NOT CARE ABOUT YOUR HOME;
DO NOT WORRY ABOUT PACKS.
RUN AWAY WITHOUT DELAY!

YEAR 1632, 16 JANUARY
IN THE REIGN OF PHILIP IV EMMANUEL
FONSECAY ZUNICA,
COUNT OF MONTEREY VICEROY